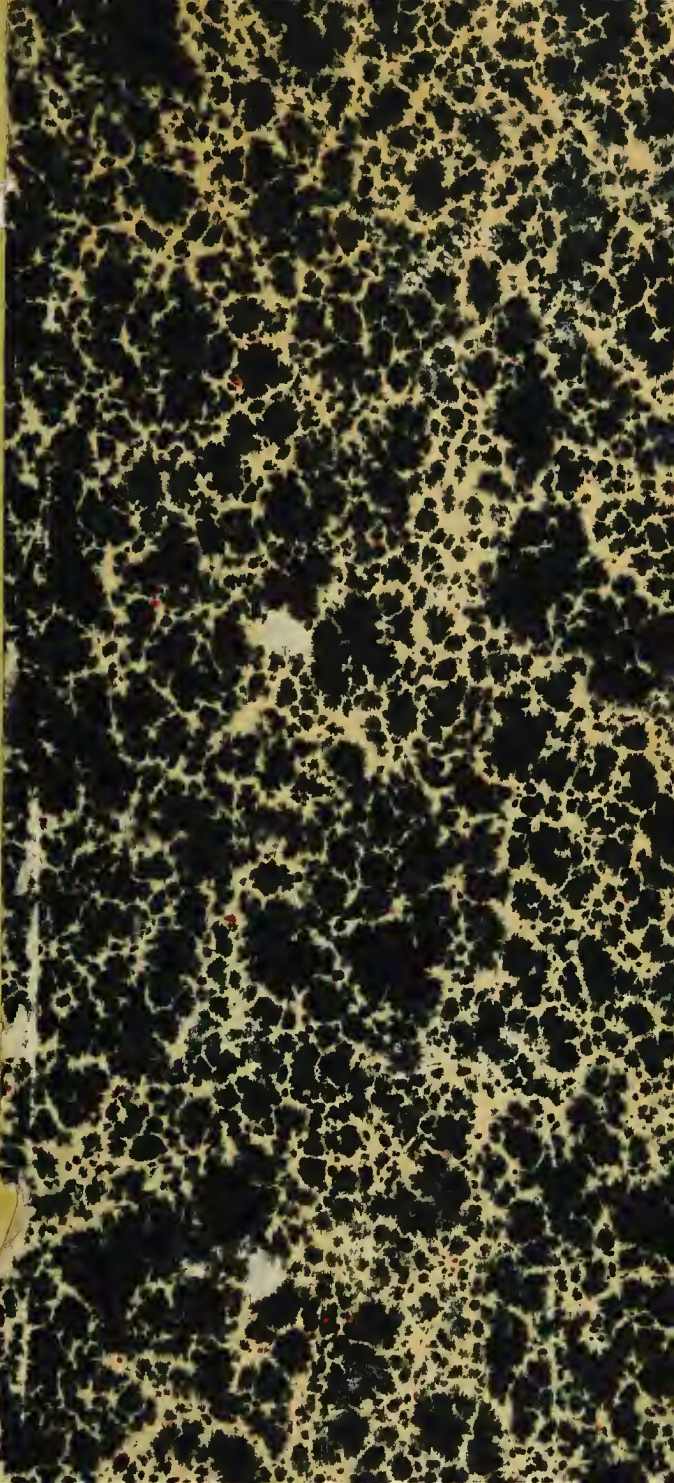
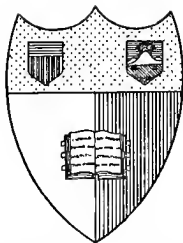


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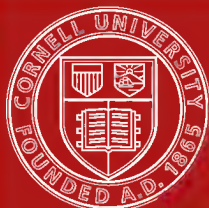
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THE ROMANES LECTURE

1915

Science and the Great War

BY

E. B. POULTON, D.Sc., M.A.

FELLOW OF JESUS COLLEGE ; HOPE PROFESSOR OF ZOOLOGY
PRESIDENT OF THE LINNEAN SOCIETY OF LONDON

DELIVERED

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SCIENCE AND THE GREAT WAR

WHEN I was honoured by the invitation to deliver the Romanes Lecture I made up my mind to speak on the relationship between newer and older conceptions of evolution. But this and every other subject which might be chosen by a naturalist in ordinary years seemed to shrink away under the great and overshadowing menace of the war. In this struggle science has played, and will continue to play, a tremendous part. It seemed appropriate, therefore, that a scientific man should take as his subject the bearing of science upon the great war, all the more so when he is convinced that we must employ science a great deal more than we have done in order to achieve success.

I do not propose to say anything of the causes which led up to the war, or to dwell upon the state of preparation in which we found ourselves at its outbreak. I cannot share the strong views of a friend who feels 'that any civic spirit which we have expended during the past twenty years has been devoted to the maintenance in authority of one or other of two sets of scoundrels who have been content to let the people of this country live in a fool's paradise'.

Our diplomacy and the state of our preparations equally show that we intended no aggressive war, while, as for defence, we were ready to do everything that had been put down as our reasonable share. No one of the allied nations had realized or could realize the deadly meaning of the organized effort and prepara-

tion carried on by Germany for a generation. No one supposed that we should be required to hold the seas and also to raise an army on the continental scale. What we set out to do was done with extraordinary speed and success. We held the seas and dispatched an expeditionary force of moderate size, which forthwith proved itself to be of the very highest efficiency.

My object is to consider some of the steps we took or failed to take when the real nature of the German menace became evident. And I shall attempt to show that the failures which have occurred are nearly all due to the national neglect of science and the excessive predominance in Parliament, and especially in the Government, of the spirit that is most antagonistic to science—the spirit of the advocate.

It would not be right to speak on the national neglect of science without acknowledging with gratitude the patriotic position taken for many years by the journal *Nature*. If only the warnings given again and again in its pages had been heeded, I am confident that long before this time Germany's complete defeat and the freedom of the world would have been achieved.

First, then, it is necessary to show what the national attitude towards science has been and now is. The following indications are just scattered examples which have caught my attention or have happened to enter into my own experience.

The fiftieth anniversary of the 'Chemical Society of France' was held in Paris on May 16–18, 1907. At the banquet, on May 16, M. Pichon, Minister of Foreign Affairs, in an eloquent speech, pointed out the advantage to the whole civilized world of such amicable meetings of scientific men of all nations, united in the common wish to promote science, and thus advance the well-

being of the human race.¹ To mark their sense of the occasion, the French Government had offered decorations of the Legion of Honour to eminent scientific representatives of the nations who had sent delegates to the meeting. They were offered to the following British guests: Professor Meldola, Sir Wm. Perkin, Sir Wm. Ramsay, and Mr. W. F. Reid. But under the regulations of our Foreign Office—those in force at the time were signed by Lord Salisbury and dated August, 1885—no foreign Order might be accepted by a British subject except for naval, military, or diplomatic services, or for rendering ‘valuable service to the Sovereign bestowing the Order outside her Majesty’s dominions’. An intelligent reading of this last clause would have admitted that the isolation for the first time of a new constituent of the atmosphere was a most valuable service, in that it thrilled the imagination and inspired the intellect of France, and indeed of the whole civilized world. And if time were available it would be easy to show that all four of the British guests had brought priceless gifts—intellectual pearls to be trampled under foot by the British Foreign Office. Would not a patriotic Government have been glad to know, and glad that the world should know, that its citizens were honoured in a foreign land for their discoveries; would they not have altered their regulations if the words were such as to suggest to dull minds a stupid interpretation? How dull and how stupid can only be realized when we think of the acts that *are* acclaimed by our Foreign Office as ‘valuable service’. A chairman or managing director of a company that employed an engine-driver and used its rolling-stock to carry so many kilogrammes of foreign monarch or foreign President would be deemed to have

¹ *Nature*, May 30, 1907, p. 112.

done 'valuable service'! And some people speak of science as tending towards a low and material outlook! Our scientific men were denied the recognition accepted by Italians and Germans, while the French Government and the French Chemical Society were rudely treated,—and all this on the strength of regulations signed by a statesman who was himself keenly interested in science!

The attitude towards science and learning which I have reason to fear is common in the army is illustrated by the words of a British officer I met, while travelling through Canada in the autumn of 1897, with a number of scientific friends—members of the British Association. When he realized that we were a scientific party he asked us whether we knew a certain officer who, he said, had become a 'bloke' and held some kind of 'blokeship'. This was his genial way of showing his respect to his fellow travellers, and also to an absent brother officer who was the most distinguished living exponent of his particular branch of learning. This is the kind of wind—a poison gas more deadly than any German invention—which has not indeed brought the whirlwind but has sapped the strength of our defence.

To take another example. I once expressed the opinion that the greatest mistake of the Boer War was made by Lord Roberts when he neglected to fortify the waterworks of Bloemfontein and so compelled the troops to use the infected wells of the place. The reply of one closely associated with the military life was, 'You make a mistake in blaming Lord Roberts. It was the fault of his principal medical officer, who was not strong enough to insist on the Commander-in-Chief providing the guard.' This seems to me a very significant saying. Instead of science, in this case the science of health, being an

essential thing which the leader must secure first of all as a foundation for everything else, it is revealed as something outside, something to be neglected until the nuisance of listening to its demands becomes more intolerable than the nuisance of acceding to them. And this, I am afraid, is too often a true picture of the attitude of the Government and the public opinion of the country towards science.

Professor Perkin has shown, in this year's presidential address¹ to the Chemical Society, that the coal-tar industry, founded on the discoveries made by his father, now leads to our annual purchase of colouring matters to the value of £2,000,000, of which 90 per cent. comes from Germany; furthermore, that these dyes are essential to our textile industries, representing at least £200,000,000 per annum and employing 1,500,000 workers. He traces the decline of the coal-tar industry and its gradual transference to Germany, beginning during the period 1870-5, to the insufficient number of first-rate British chemists necessary for developing the existing processes, and especially for the all-important work of making new discoveries.

The same failure is apparent in other industries, as was shown by Professor Perkin in his evidence before the consultative Committee of the Board of Education—

¹ The whole address should be carefully studied, as also the lecture delivered in Oxford by Professor Meldola in 1903 (*Nature*, Aug. 27, 1903, p. 398). I cannot forbear to speak of the grievous loss which the country has just sustained in the recent death of this great man. Meldola was the one scientific man to whom we were looking for guidance in the period of reconstruction after the war. And he was to have occupied a position in which his great knowledge of science and industry would have had full scope, having been appointed on the council of the recent 'Scheme for the Organization and Development of Scientific and Industrial Research'.

a large Committee which dealt with Scientific Education and Research and yet had not a single scientific man upon it! In the course of his evidence Professor Perkin expressed the opinion that 'it is entirely due to our lack of appreciation of the importance of research that so many of our industries have already gone to Germany and so many were in process of being transferred when the war broke out'.

The causes of failure Professor Perkin traced back to the Universities and the schools. He showed that there are roughly ten times as many advanced students doing research in Universities and other teaching institutions in Germany as there are in this country; and, speaking of the traditions in our schools, 'Over and over again', he said, 'I have met men who have told me that, while their natural bent had always been "in the direction of science, they had taken up a classical career because they had been urged to do so by the head master of their school'.

I have heard the late Sir Arthur Rücker express the opinion that scientific education in this country would never have a fair chance until a scientific man was made head master of one of our great public schools.

I would not for a moment undervalue what is done for science or the great improvement that has been effected in the teaching of science in the public schools. But with all this, for which we are most grateful, there exists a distorted estimate of values. A clever boy is thought to be wasted if he does not study classics.

I may instance an example which came under my own personal experience. I refer to a boy I knew well who in my opinion was intended by nature for a scientific career. The conviction grew ever since a day in his early childhood when I explained to him that nothing

was really lost when a burning candle gradually disappeared, and he listened patiently and then said, 'I think I knew that when I was born'. But he was quite good at classics, and when, in the course of his public school career, it was considered that the time had come for him to work at science, his housemaster wrote to his father lamenting that he had chosen the lower part. The master was a mathematician, but then mathematics, being an ancient study, often prides itself on its aristocratic association with classics.

I trust I shall not be misunderstood in what I have said of the public schools. The spirit there fostered is one of the most precious possessions of the nation—how infinitely precious it is we never realized in full until now in our time of trial. One of our greatest hopes for the future rests in its growth throughout the community. And this bright hope is encouraged by the knowledge that the public school spirit is in no way dependent on the learning of classics, but is shared in equal measure by those who study science.

We look to the public schools more than to any other influence to rescue us from a dangerous condition; for it is dangerous that a country which depends on science for its existence and prosperity should be ruled by politicians and civil servants with hardly an exception utterly ignorant of science.

It is important to remember too that a scientific training brings other benefits besides the knowledge of science, benefits we terribly need to-day. It is not mere accident that has made all-round efficiency and competence, in this time of stress, so conspicuous in those departments which by their very nature are founded on science and must always keep in touch with science—the Navy and the Medical Service. And what

a scientific training has done in these careers it would effect in bracing the whole of our national life, leading to the cure of those faults of which the Bishop of Winchester spoke with such straight and wise words in his Visitation Charge delivered on September 28. He then traced the 'ludicrously insufficient measure' taken early in the war 'of the mighty strength and skill of the great German war machine' to 'that easy, amateurish way of handling great issues which now more than ever was seen to be our inveterate and perilous characteristic. It meant a great national complacency, allowing, and fed by, great inertness of thought'.

I now turn to difficulties of another kind which must be faced and overcome. The scientific man, whatever be his capacity or value, rarely has the opportunity of entering Parliament. At the present time the barrister is the only member of the community who benefits by seeking a political career, and for this reason he is certain to be over-represented, certain also, by the very nature of his profession, to be too powerful. The danger would not be nearly so great if the lawyer in Parliament and in the Government did not almost invariably mean the advocate. Hence by the conditions of education and the means of making a living in this country, not only is the scientific spirit excluded from Parliament, but the spirit of all others the most antagonistic to science is invited to enter and to rule. The advocate labours to give to his case, whether true or false, the appearance of truth: the scientific man labours to strip off appearance and discover whether the true or the false is hidden beneath. Huxley once told how a rich friend of his youth was sure that he would make a successful barrister, and offered to back the opinion by financial assistance. 'I told him', said Huxley,

‘I believed that such abilities as I possessed lay in the direction of the discovery of truth rather than the obscuring of it.’

It is a curious and unfortunate circumstance, and not without its bearing on the present condition, that when the advocate meets the scientific man as a witness he too often encounters another advocate rather than a scientific man. A clever Scotchman, speaking of an action in what he had been engaged, told me that he was particularly glad when he knew that the opposite side was calling Lord Kelvin as a witness, ‘because he is so inflexibly honest’. But the sting in these words is only for the expert witness, by no means for the barrister whose position is understood by every one. We must recognize to the full that, in its professional sphere, the work of the advocate is essential to the community, and that the experience of ages has failed to discover any other way of doing it. But in the quite different sphere of legislation, and especially government, too much of the advocate’s spirit is dangerous: in a terrible crisis when law inevitably shrinks into the background, it is disastrous.

The parliamentary ordinance issued in 1372 by Edward III forbade the election of lawyers. The writs of the following year were very explicit: ‘The knights of the shire are to be belted knights or squires, worthier and more honest and more expert in feats of arms, and discreet, and of no other condition; the citizens and burgesses are to be chosen from the more discreet and more sufficient of the class who have practical acquaintance with seamanship and the following of merchandise; no sheriff or person of any other condition than that specified may be chosen.’¹

¹ Stubbs, *Constitutional History*, Library Ed., 1880, iii. 432.

Henry IV was not satisfied with the result of this method of exclusion. It may be suggested that lawyers managed to evade the purpose of the writs by taking shares in a ship or a business. It is at any rate clear that the king knew they were extremely difficult to keep out ; and in 1404, when England was beset with troubles from France and Wales as well as from within, he took a strong line, and in the writ of summons ' directed that no lawyers should be returned as members. He had complained more than once that the members of the House of Commons spent more time on private suits than on public business ; and the idea of summoning the estates to Coventry, where they would be at a distance from the courts of law, was perhaps suggested by his wish to expedite the business of the nation.'¹

The exclusion of lawyers seems, then, to have been brought about by four distinct steps—the ordinance acted upon by both kings, the writs describing the eligible persons and omitting lawyers, the writs expressly excluding lawyers, and the meeting of Parliament in Coventry instead of London. The ' Unlearned Parliament ', as it was named, probably by the lawyers, met in October, 1404, and apparently justified the king's action by getting through a great deal of important business in providing the means for the wars.

We should not to-day think very much of the reasons which influenced Henry IV, although certainly the galaxy of talent which was employed to prosecute and defend the ordinary German spy Lody was an extraordinary demonstration of the unreality of war as waged by lawyers. Justice, of course, the man was entitled to, and justice he would always get in this country, but the unnecessary parade and glory of his trial were the very

¹ Stubbs, *Constitutional History*, Library Ed., 1880, iii. 49.

things to appeal to the megalomania of his compatriots. Then later on we read that two other spies were to be tried before three judges, including the Lord Chief Justice, that the prosecution would be conducted by Sir Edward Carson, just then appointed Attorney-General, and that the defence would be in the hands of a K.C. and three other barristers! It would be interesting to know whether the fees of counsel employed in such trials will be taxed as profits due to the war. It is unnecessary to say more about this and other wasteful expenditure on law by a lawyer-dominated Government, which has urged the nation to deny itself in every possible way.

The great danger of the lawyer-politician in a time of supreme crisis is that he has been accustomed to live in an atmosphere of compromise, of action based on reasonable discussion between opposing interests, of scrupulous attention to precedent. But when, under entirely new conditions, we cannot follow history but are compelled to make history, then the spirit of the advocate is the worst possible guide. In that spirit the Declaration of London, drawn up in 1908 and rejected in 1911, seems to have been put into force by the Government at the beginning of the war. It is an instrument which might have been prepared by agreement between a clever barrister representing Germany and a dull one representing this country. While it was in operation it served to diminish the power of our fleet, to legalize the action of the *Emden*, and to provide President Wilson with a convenient handle to be used against us. Article 57, only got rid of by the Order in Council of October 25 last, 'provided that the neutral or enemy character of a vessel is determined by the flag she is entitled to fly'. Think of

it! To have had experience of Germany as a foe for fifteen months and yet voluntarily to keep in force for the whole time an article which assumes that a German ship flying a neutral flag must be neutral! It would be incredible did we not know that it is true.

Another astounding incident in lawyer-conducted war was the order in force at one time, forbidding the captains of His Majesty's ships to arrest German and Austrian reservists on their way across the sea to join their regiments.

Again, it would be interesting to know why the enemy's trade was not attacked by our submarines in the Baltic until last October, when such action would not only have been a great injury to Germany, but would also have provided an answer to objections that our blockade unfairly discriminated in favour of Norway and Sweden. It may be that submarines of the necessary radius of action were not available until October, but we are told very little, and unfortunately are compelled to fear very much in the conduct of the war by a Government that has paid but little heed to the characteristics of the British people.

The most interesting and amusing of the Romanes Lectures which I have had the pleasure of hearing was that on 'The English National Character', delivered in 1896 by Dr. Mandell Creighton. 'In nothing', said the lecturer, 'is the peculiarity of the English character more strongly emphasized than in the curious prominence which it has always given to the claim for free expression of opinion.' And he noted how Tennyson has seized hold on this 'abiding product of a nation's past' when he speaks of England as

'A land where girt by friends or foes
A man may speak the thing he will'.

Dr. Creighton gave amusing illustrations of this strongly marked characteristic, going far back in our history. 'At the beginning of English literature stands Langland, burning with a simple Englishman's desire of saying his say about things in general. Hugh of Lincoln took Henry II by the shoulder and gave him a good shaking, when he petulantly refused to listen to him. Grosseteste hunted Henry III from place to place, as the king fled before the scolding which he knew was in store for him.' 'The truth is every Englishman likes to express his opinion, if he takes the trouble to make one.'

But now in this tremendous crisis every Englishman, however lethargic he may have been in less exciting times, is bound to have his opinion. And when the war is profoundly and, as experts maintain, disastrously influenced by vital decisions put into operation without explanation and as silently withdrawn, opinions that are helpful neither to the Government nor the country are bound to be expressed. When an Englishman ascertains that, by Article 28 of the Declaration of London, all kinds of material necessary for the conduct of war may not be made contraband, he is left hesitating between flabby sentimentalism and concealed German influence. He may be entirely wrong in this, and I hope he is. The fault is the Government's, which after making momentous and on the face of them disastrous decisions is satisfied to withdraw them without a word of explanation.

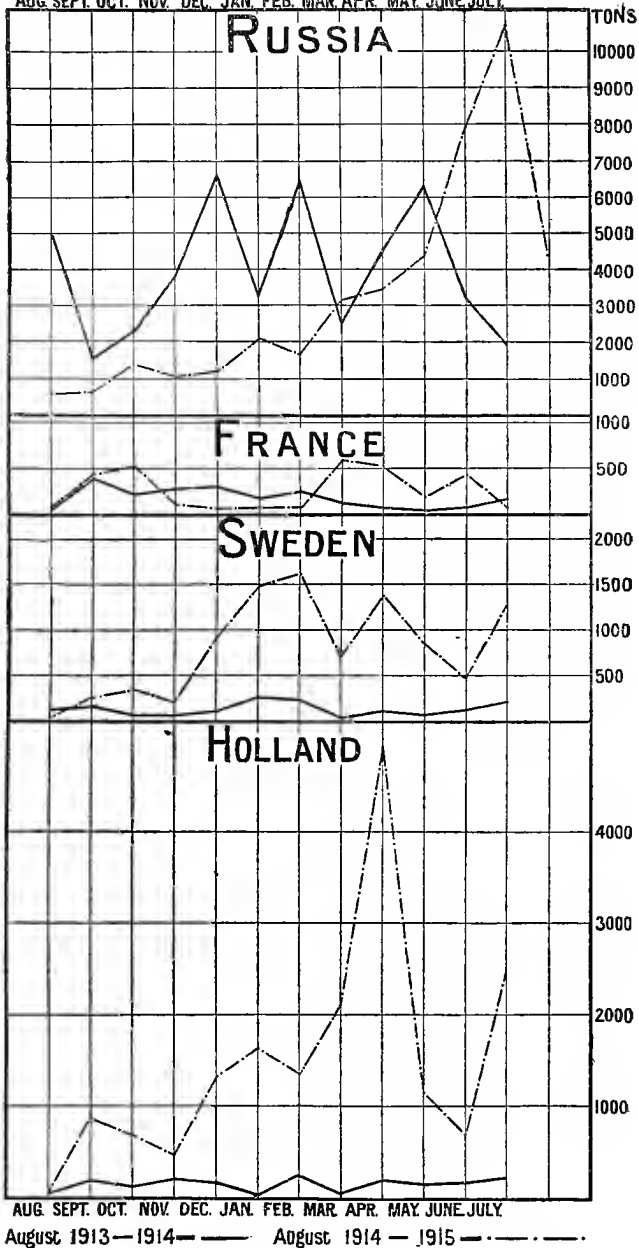
The conduct of the war by lawyer-politicians has recently been defended by one of their number. The line of argument he adopted is important for the subject of this lecture as it leads direct to one of the most terrible mistakes that has followed the neglect of science. Sir F. E. Smith is reported in *The Times* of November 5,

1915, to have said: 'If he could grasp the strategic conceptions and explanations of those who wrote about them, the unexpected withdrawal of Russia and other misfortunes were principally chargeable to the defects of our lawyer-politicians.' Later on in the same speech he is reported (in the *Morning Post*) to have stated that the Russian retreat was 'occasioned solely by inferiority in munitions'. But why had Germany this superiority? Because lawyer-politicians, fixing their attention more steadily, as we are compelled to believe, on neutral friendship than on German defeat, permitted the export from this country of the materials essential for propulsive ammunition—cotton, fats, and oils. The lines on the opposite page speak for themselves, showing that from the beginning of the war up to the end of last May, while we were sending about the same quantity of cotton to France as that sent in the corresponding months of the previous years, and to Russia much less, the amounts to Sweden and Holland, the two mouths of Germany, were enormously greater. Sir F. E. Smith did not exhibit the usual astuteness of an advocate in choosing his line of defence. In the immense increase of the export to Russia, which began in June last, we probably see a result of the disastrous explosion at the great munition works.

The attitude of the Government towards science is well illustrated by the efforts that were required before this injurious policy could be reversed. We owe the final success to the patriotism of a scientific man, Sir William Ramsay, who was most unwilling to begin the campaign in the press by which alone the Government could be moved. Let those who abuse the press remember that. Sir William is a member of the Royal Society Committee to advise the Government on

COTTON FROM THE U.K. TO:-

AUG SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY



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August 1913—1914— — August 1914 — 1915 - - - - -

scientific matters, and he sought personal interviews with many people in authority, but nothing could be done in these ways: the press remained as the last and only hope of saving our men from the results of the acts of our own Government.

Sir William Ramsay traces the origin of this fatal policy to the erroneous suggestion of substitutes made by an eminent lawyer-politician, who 'at the beginning of the war gave as his opinion that it would be useless to make cotton contraband, as there were so many substitutes for it which the Germans could use'.¹ Concerning the possible use of nitro-cellulose from vegetable fibre other than cotton, it is sufficient to say that ammunition made from it could not be safely used in large guns, and that its power would be different from that of gun-cotton, so that weapons designed for the latter would have to be altered.

The Marquess of Crewe, in replying to Lord Charnwood's question about cotton, is reported to have said 'it would naturally not do to assume that no substitute, even if less convenient, can be found in all cases. I do not say that to minimize the importance of keeping raw cotton and cotton-waste out of Germany, but I do not go so far as my noble friend in speaking of its necessity.'²

Surely the 'necessity' was upon our Government to prevent Germany having any advantage that we could deprive her of; and it was idle, especially for a speaker unbacked by expert opinion, to attempt to discriminate between what is 'important' and what 'necessary' to the enemy.

In the debate on the sugar duties, on March 9, 1759,

¹ Quoted by Sir William Ramsay in his letter, *Morning Post*, July 19, 1915.

² *Ibid.*

Chatham began 'Sugar, Mr. Speaker', when he was interrupted by a rude laugh. 'Sugar, Mr. Speaker,' he continued, 'Sugar, Mr. Speaker: who will laugh at sugar now?' That is the spirit the nation would have welcomed in its rulers at this time of deadly crisis when cotton and oils and fats for German ammunition are among the decisive factors of the war.

It was unfortunate and not, I think, creditable that this agitation, begun unwillingly from a sense of public duty, should have been weakened by the words reported¹ to have been used by a scientific expert speaking at the annual meeting of the Society of Chemical Industry at Manchester last July: 'It has been stated in some daily papers that cotton is absolutely necessary for the production of high explosive shells, and you will hardly believe that there is practically no cotton used in the manufacture of high explosives. The whole thing is a great fraud.' Words such as these could only serve to confuse the public mind and encourage the erroneous belief that there was nothing in the effort to prevent cotton reaching Germany. The words would lead all who heard them or read them in the press to lose sight of the vital fact that cotton is absolutely necessary to enable the shell to leave the German gun, and that without cotton the high explosive in the shell could do no harm whatever.

It is now necessary to consider the question of oils and fats, at the present moment far more important than cotton because the Government is still permitting their export in vast quantities. Lord Robert Cecil is reported in *The Times* of July 27, 1915, to have said: 'I listened with positive amazement to my hon. friend [Major R. Hunt] when he said that we are saying to Germany,

¹ *Morning Post*, July 17, 1915.

“We will allow you to be provided with ammunition with which to kill our soldiers”.’ But surely the speaker ought to have known that the then Solicitor-General, Sir F. E. Smith, had only a week before announced a wonderful ‘new discovery’, made in 1779, which bore very directly on the provision of ammunition for Germany. In the performance of professional duties which required some knowledge of fats as a source of explosives the Solicitor-General is reported in *The Times* of July 21 to have announced, in the Prize Court concerned with alleged contraband from America, ‘that it had recently been discovered that glycerine could be made from lard’. *The Times*, too, accepted and proclaimed the absurd blunder in large capitals at the head of the paragraph.

In order that our lawyer-politicians and the powerful but silent services which they represent in Parliament may know what their neglect of science has done and is doing for our enemies, I will now state as briefly as possible the essential facts concerning the making of powerful smokeless, propulsive ammunition of every kind as used for military purposes.

The fact that a ‘sweet principle’ can be extracted from oils and fats was probably known long before 1779, when Scheele, a Swedish pharmacist and great discoverer, first definitely separated glycerine in the preparation of lead-plaster by boiling lard or olive oil with litharge (oxide of lead). The purification of glycerine by steam-distillation was patented in 1855. The conversion of glycerine into the powerful explosive trinitro-glycerine, a heavy oily liquid, was first effected in 1847 by Sobrera, and on a commercial scale by Nobel in 1863. The great dangers attending the use of the new explosive were removed in 1866-7, when Nobel con-

verted it into 'dynamite' by the addition of an infusorial earth. Absorbed and retained by this or some other inert solid substance, the liquid explosive can be safely stored, transported, and used.

The essential constituents of all the most powerful military smokeless, propulsive ammunition are gun-cotton (nitro-cellulose) and nitro-glycerine.¹ Hence cotton for making the one and oils and fats for the other are necessary to any country engaged in a modern war and unable to import the finished product.

On the subject of oils and fats I wrote to the press (*The Times* for September 18 and October 23) most unwillingly, and only when told by friends on one of the war committees of the Royal Society what was being permitted by the Government. I mentioned in the earlier letter that 'a friend interested in chemical works told me that it had come to the knowledge of his firm that there was a practical process for making glycerine from a certain material not previously used for the purpose. The firm informed the authorities, and within forty-eight hours the export of that material was prohibited.' There is no necessity for maintaining secrecy any longer, for the prohibition of the substance, linseed oil, was published in the papers on December 3,

¹ Besides these essential ingredients military propulsives contain small quantities of (1) *Moderants* or *Deadeners*, to reduce or control the rate of combustion, e. g. paraffin, vaseline, castor oil, &c. (2) *Stabilizers* to act upon and fix the injurious products of decomposition during storage. Vaseline in cordite has this effect as well as that of a moderant. Aniline has the advantage that it indicates by changes of colour the existence and progress of decomposition. (3) *Cooling agents* to reduce the temperature of the explosion and its effect on the bore of the gun, and to diminish the flame. For further details see the article 'Explosives' in Sir Edward Thorpe's *Dict. of Appl. Chemistry*.

but it is not a prohibition for which the present Government can claim any credit. Far from it. It is indeed a revelation of the dangers to which we are brought by the neglect of science when in the most terrible crisis of our national history 'success or failure in arresting the supply of materials for making German explosives depends upon the patriotism of a firm willing to sacrifice their profits for the sake of national gain, instead of upon a Government issuing resolute orders based upon expert knowledge'. Equally disturbing was the receipt of a letter from a business man who was patriotically helping the nation, asking me, a naturalist, for advice about oils and fats, because to seek such information through Government channels was 'at best a lengthy and unsatisfactory method'.

The following letter from Sir William Ramsay shows that our French allies are fully alive to the danger which our Government refuses to avert: 'I am constantly having letters from France asking me to do my best to make fats [and oils] and their sources contraband. It is the last stuff required for ammunition by the Germans. Copper, nitrate, cotton are now absolute contraband: fats remain. One-third of German ammunition for heavy guns consists of nitro-glycerine; and fats [and oils] are the only source of glycerine. I really can't understand the incredible folly of going on providing these brutes with the means of killing our men.' And Lord Robert Cecil is positively amazed when we say that the Government allows Germany to be provided with ammunition for this very purpose.

What a grave responsibility has been incurred by the Government in deciding these vital issues without scientific evidence, and in clinging to their mistake in spite of the efforts of those who know. Untold thousands

of lives and an ever-growing volume of human misery are a terrible punishment for the neglect of science.

I come now to an entirely different aspect of the war, but one in which the Government requires the aid of science just as fully as in the provision of ammunition. It is possible that military experts are mistaken in thinking that the final decision can be reached by fighting. It may have to be reached by economic and financial pressure. And in any case such pressure, if it can be exerted, is certain to have an immense influence upon the war. A Warsaw banker, I. S. Bloch, after immense labour carried on for many years, published in 1897 six volumes on *The War of the Future*. Two years later, an English translation of the last volume, with the title *Is War now Impossible?*, was brought out in London. The writer was not considering in his work the wars of small nations or small wars on the outskirts of great empires: he was thinking solely of struggles like the present. He was obviously wrong in some of his conclusions. Thus he believed that the day of the bayonet was entirely over. He over-estimated the financial difficulty, considering that an expenditure, estimated at that time, of £4,000,000 a day for the maintenance of the mobilized troops of the Triple and Dual Alliances would be an impossible burden. And he greatly exaggerated the danger of swift economic and social ruin in the warring states. But he saw very clearly a great deal that military experts have failed to see. The magazine rifle of small calibre with smokeless powder, immense range, and flat trajectory, the even greater improvement in artillery, together with the social and economic conditions of the modern state, were the data from which he drew his conclusions. They are most easily conveyed in a few extracts from a

conversation with the late W. T. Stead, which is printed as a preface to the English translation.

Speaking of a battle with modern weapons he said :

‘At first there will be increased slaughter—increased slaughter on so terrible a scale as to render it impossible to get troops to push the battle to a decisive issue. They will try to, thinking that they are fighting under the old conditions, and they will learn such a lesson that they will abandon the attempt for ever. Then, instead of a war fought out to the bitter end in a series of decisive battles, we shall have as a substitute a long period of continually increasing strain upon the resources of the combatants. The war, instead of being a hand-to-hand contest in which the combatants measure their physical and moral superiority, will become a kind of stalemate, in which neither army being able to get at the other, both armies will be maintained in opposition to each other, threatening each other, but never being able to deliver a final and decisive attack. . . . That is the future of war—not fighting, but famine, not the slaying of men, but the bankruptcy of nations and the break-up of the whole social organization’ (pp. xvi, xvii).

‘No decisive war is possible. Neither is any war possible . . . that will not entail, even upon the victorious Power, the destruction of its resources and the break-up of society. War therefore has become impossible, except at the price of suicide’ (p. xxxi).

‘Everybody will be entrenched in the next war. It will be a great war of entrenchments. The spade will be as indispensable to a soldier as his rifle’ (p. xxvii).

‘All wars will of necessity partake of the character of siege operations’ (p. xxxviii).

‘Your soldiers may fight as they please; the ultimate decision is in the hands of *famine*’ (p. xlix).

One final quotation which, had she taken it to heart, would have saved Germany great treasure and much bitter disappointment.

‘Unless you have a supreme navy, it is not worth while having one at all, and a navy that is not supreme

is only a hostage in the hands of the Power whose fleet is supreme' (p. lvi).

Now it will be admitted that these predictions have in great part been proved to be true. Think of the description of modern war given in *The Times* of July 31, 1915, by an officer in the Royal Engineers. Of everything that made the pomp and circumstance of war as it was wont to be he says: 'They are all gone, every one, and nothing is left but the deep and dirty trench, the immutable outlook on the immutable enemy, the maze of alley-ways in the rear, and the mole-like progress of the saps and alleys in front.' The vital question then arises: what about the rest of Bloch's anticipation? Will that, too, be fulfilled? Will the end of the war be brought about by famine, national bankruptcy, and the break-up of society? It is bitterly to be regretted that the Government did not very seriously consider this possibility at the outset, making their preparations as if this might be the end for one or both of the belligerents. If they had done so, the war, as I hope to show, would have been over long ago. The insufficiency of the food-supply of a besieged Germany would have brought it to a close.

At the very beginning of the war the scientific men of Germany knew that this was their great peril. They studied it, and in December, 1914, brought out an exhaustive memoir on their food supply, *Die deutsche Volksernährung und der englische Aushungerungsplan* ('Germany's Food and England's plan to starve her out'). It is written by Professor Eltzbacher with fifteen distinguished colleagues, nearly all of Berlin. The preface states that an exact study of the nation's food during war required the aid of 'the politician, the political economist, the statistician, the physiologist,

the farmer, the geologist, and even the experienced housekeeper'. In Eltzbacher's work is revealed more clearly than in any other publication accessible to us the spirit we have to encounter, a spirit which official neglect of science has rendered us so unfitted to overcome. And it is not only a revelation of spirit but an inventory of food in which nothing is neglected.

A few examples will suffice.

Starching means that human foods 'are being used to make our clothes less comfortable, though in the opinion of many people more beautiful' (p. 91). Those who are interested will find set down the precise number of fruit trees—apple, pear, plum, and cherry—counted in Germany in 1900, together with an estimate of their probable number on January 1, 1913 (pp. 45, 46). The available resources of meat are estimated not only from 2,000,000 tons of pig but also from 100 tons of dog (p. 57).

The revelation of German resources is in fact so complete that I believe the work was considered dangerous and has now been suppressed. This, however, is too late, for an excellent English translation has already appeared.¹

It has always seemed to an Englishman that the life of the German people was State regulated to an intolerable degree, but *now* says Eltzbacher, 'Our economic life is subject to State regulations to an extent hitherto unheard of. . . . Patriotic feeling has, however, accepted this far-reaching State regulation as absolutely justified. Nowadays everyone is a Socialist, so to speak' (pp. 9, 10).

It is well that we in the British Islands should realize

¹ *Germany's Food, can it last? A Study by German Experts*, edited by Prof. Paul Eltzbacher, of Berlin. English version edited by S. Russell Wells, M.D., with a critical introduction by A. D. Waller, M.D., F.R.S. London, Hodder & Stoughton, 1915.

and take into account the indomitable spirit which lives in the following passage:

'To-day it does not matter whether a farmer or a manufacturer prospers or whether a company pays dividend, but we have all got to live. It is not a question of money at all, but of bread, meat, and potatoes. This is constantly being overlooked by many classes; for instance, certain persons interested in sugar are doing all they can to induce the Government either to permit the export of sugar or to keep up the price of sugar at home by fixing minimum prices or making similar regulations. Many people support these endeavours on the ground that money must be earned somehow. The argument is not sound. There is no need to earn money. We are all making sacrifices in these grave times, and the sugar producers and dealers will have to join us for good or evil. The fulfilment of their wishes would be a betrayal of the Fatherland's interests.

'In order to do all that has to be done to meet our deficit we must make use of the gift which marks us out from other nations—capacity for methodical and determined action' (pp. 81, 82).

How our enemies reckoned on the articles of the Declaration of London is all set forth, together with the admission that England has not yet ratified it. They enumerate the oil-yielding materials of various kinds and the nitrates which, under this instrument, cannot be declared contraband (p. 12).

Germany, we are made to realize, is at war—not at law, nor going to endanger her cause by a too nice consideration of neutral interests.

'No political considerations demand the surrender of vital interests' (p. 95). It would be 'a mistake to permit the export of grain to Switzerland out of consideration for that country; the wish to help a friendly nation ought under no conditions to increase still further the difficulty of feeding our own people during the war' (p. 84).

'Whatever happens we must avoid sharing our food-stuffs with the foreigner. If there ever was anything

which should be held on to with iron determination it is the prohibition to export foodstuffs issued immediately after the beginning of the war' (p. 83).

Many of the measures advocated in this work have been put in force, such as the prohibition of sugar export, the slaughter of pigs, the employment of prisoners in cultivating the ground, and many suggestions as to foods and their preparation. The reduction in the stock of pigs has been adversely criticized, but it seems to have been perfectly sound advice under the circumstances; for 'the pig is man's greatest competitor in food'. It is amusing to hear a German thus say for himself what has often been said for him in slightly different words. But, seriously, it is impossible to recognize any mistake in the policy when 'with the milk, grain, and potatoes which a pig devours we could feed twice as many people as with the resulting pork' (p. 86).

The most essential part of Eltzbacher's work is the attempt to show how the necessary food-supply of Germany's 68,000,000 can be met without imports. Food is considered under its two great divisions :

(1) *Body-builders and repairers*.—Protein, chiefly contained in meat, eggs, milk, peas, beans, kernels, grain, &c.

(2) *Energy-producers*,¹ yielding heat and work.—Fats and oils (hydrocarbons), with sugar and starch (carbohydrates).

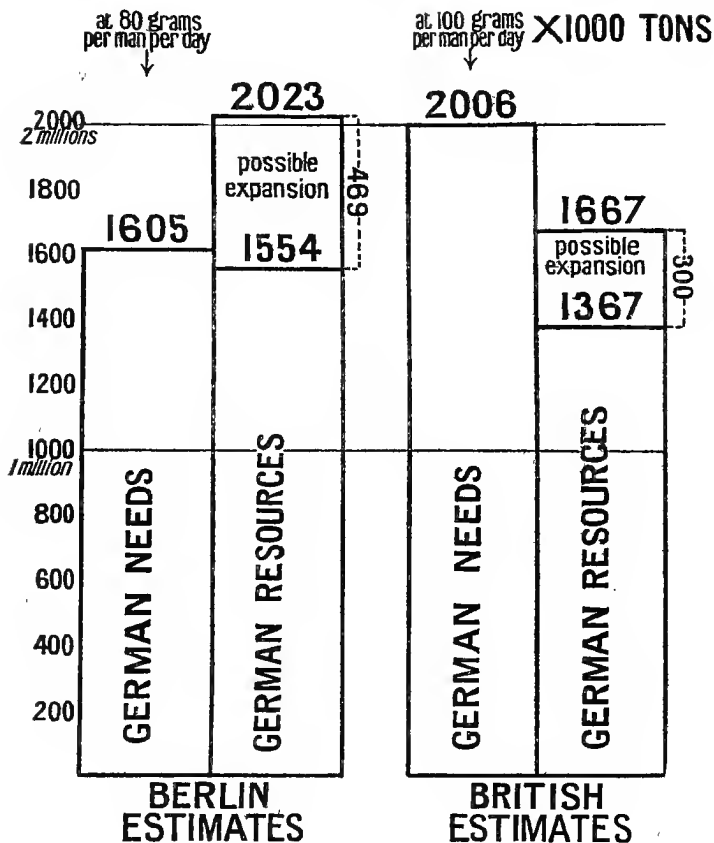
The body, in fact, resembles a locomotive, which requires metal for repair and fuel to enable it to move. The body is like the engine in that its fuel is useless for repair: it is unlike in that it can employ its metal as

¹ The value of energy-yielding foods is expressed in calories, one calorie being the heat required to raise 1 kilogramme of water from 0° to 1° centigrade.

a very uneconomical form of fuel ; for protein, the most expensive and the only essential form of food, yields but the same amount of energy as sugar and less than half that of fat.

Germany is in a far more serious position as regards the supply of protein than of energy-producing foods, so that we need not further consider these latter. Eltzbacher contends that the quantities represented on the left-hand side of the diagram on p. 30 are a true statement of German protein needs and the means for more than meeting them. He claims that the yearly needs (1,605,000 tons) for the 68,000,000 people are very nearly met by existing resources (1,554,000 tons), and that it will be possible by special efforts to increase the resources to more than 2,000,000 tons. The data on which these conclusions are based have been subjected to a searching examination by Dr. A. D. Waller, Professor of Physiology in the University of London, and Professor W. J. Ashley, holding the Chair of Commerce in Birmingham University. These authorities concur in the opinion that the German case is stated far too optimistically. Dr. Waller's conclusions are represented on the right-hand side of the diagram on p. 30 prepared by him and kindly lent to me for reproduction.¹ It is unnecessary to quote the figures, which are clearly shown, but it will be seen that Dr. Waller believes that the German needs were greatly underestimated, the resources as well as the means of extending them greatly overestimated by Eltzbacher. Professor Ashley, in a critical examination of the data in the *Quarterly Review* for October, comes to the same conclusion. It is only necessary to mention here the principal criticism, although there are many others. The

¹ I am also indebted to Dr. Waller for the loan of the diagram facing p. 16.



The total annual requirements and internal resources of Protein food of the German population (68 millions) as estimated by the Berlin committee and by ourselves. (Austro-Hungary, neutral countries and oversea supplies are not taken into account.)

PROTEIN

German professors take 80 grammes of protein per day as sufficient for a man, while the English critics consider that this is far too low for healthy existence, and that 100 grammes are necessary. Professor Ashley criticizes the policy of the German professors in proclaiming a sufficiency of food, thus bringing on a great revulsion of feeling and bitter attacks on the tradesmen and farmers when supplies became scarce and prices rose. But, knowing that the situation was really desperate, what better course could the authors have taken? They had to frighten the people into economy, and yet dared not frighten them too much. The only chance of success lay in persuading the people that their efforts would not be in vain. Eltzbacher's memoir will be found to strike the balance between these two objects—to frighten and yet to reassure—in an extremely skilful manner.

I do not entertain the slightest doubt that the English critics are right, and that, if the Government had asked for and accepted scientific advice on this subject, the war would have been over long ago.

Lord Robert Cecil is reported in *The Times* of December 3 to have said, 'Our policy was to secure our rights and to starve Germany first of all. Starving Germany was, of course, only a metaphorical expression—it was impossible; he would rather say deprive her of essential articles'. What right had Lord Robert to say that the starving of Germany was impossible? He is not an expert on food-supply and he quoted no authority. Has he studied the Eltzbacher memoir and Dr. Waller's and Professor Ashley's criticisms? Has he asked for a report from the Royal Society's Committee on the Food-supply of Germany? What we really need to end the war is *knowledge* and firm action

based on it. As it is, with its slipshod ways of conducting war and neglect of scientific authority, our own Government has done very much to help Germany out of the difficulty. It has ignored, as Dr. Waller says in the Introduction to the English translation, 'the obvious fact that the food of a besieged nation, as of a besieged fortress, in tons of bread, meat, and potatoes is as truly its ammunition as are its shells'.

Cocoa, as we are reminded on many a front sheet, is 'of exceptional food value'. We exported (in large part to Germany via Holland) during the first ten months of the war 'more than three times as much cocoa as during the corresponding ten months of the previous year'. In December, 1914, nearly $7\frac{1}{4}$ million lb. (7,232,806) of cocoa were exported to Holland as compared with under $1\frac{1}{8}$ million (1,121,415) in December, 1913. In May, 1915, the total export was over $4\frac{1}{5}$ million lb. (4,208,347) as against under $1\frac{1}{2}$ million (1,423,901) in May, 1914. But here no information as to destination is given in the returns of the Board of Trade, a circumstance which, remembering other actions of the Board and the criticism they have elicited, we are bound to view with grave suspicion.

Briefly considering a few of the British exports in the twelve months immediately before as compared with the twelve after August 1, 1914, we find about three and a half times the quantity of nuts and kernels in the later as compared with the earlier period; while glycerine, benzol and toluol, and carbolic acid, all of inestimable value in war, are but little below the amounts of the twelve months ending with July, 1914. The inference from one of our exports would be really amusing if one had the heart to be amused at the weakening of our extremely strong position by our own action. The export of sugar from

Germany was checked, because of the anticipated deficiency in oils and fats, Eltzbacher saying plainly that the people did not eat nearly as much sugar as the English, and that they would have to eat more. He pointed out that it was an excellent plan to use it as a food in combination with fruit. The British Board of Trade obligingly permitted the export (we are not told the destination but we can guess) of nearly twice the weight of oranges in seven months from December 1, 1914, as in the same period from December 1, 1913 (390,880 cwt. to 206,970 cwt.), and we are thus prepared to believe the report that, on the Empress's birthday, every German soldier was presented with a pot of marmalade!

What can be the reason for prolonging the war in this way? We are kept very much in the dark and can only surmise. The impression is gained that the Board of Trade is instructed to encourage exports in every possible way, and finds it much easier to succeed when the supply of German needs is not looked at too critically. So we have the War Office and the Admiralty trying to fight Germany while the Board of Trade supplies Germany through neutrals, and the Foreign Office takes care that the Navy does not exert too strong a pressure on her. Modern civilization has been described as 'anarchy plus the policeman'. The higher conduct of war by England seems to be anarchy unalloyed.

'It is well', as Dr. Waller says in his Introduction to the German memoir, 'that we should think clearly and *arithmetically* in the matter, as is the habit of mind of our present enemy. Loose thinking in the matter of food-supply can easily lead to or permit loose commerce, and justify a laxness of which it is inconceivable that the German fighter should be capable.'

Another possible cause of our weak policy is a natural feeling against the starvation of non-combatants. But the cutting off of supplies is one of the oldest methods of war, and, as a matter of fact, one of the least inhumane. The pressure is gradual, the inevitable can be foreseen afar off. In this, starvation contrasts favourably with every other method of war. Furthermore, it has for many years been the one plan favoured by possible enemies in attacking this country. The *Powerful* and the *Terrible* were built to avert this very danger. Whatever we may do or not do, the Germans have given us full credit for trying to starve them out, while they have undoubtedly tried their best to do the same to us, not hesitating to adopt vile and murderous methods to which no other nation could have stooped.

The principal reason for weakness in dealing with German imports is probably to be found in an oversensitiveness to neutral opinion. The impression produced upon a people that is told very little, is that our lawyer-politicians have been more concerned to keep friendly with neutral nations, and especially America, than to beat Germany. If we had from the very first stopped, not only cotton, fats, and oils for making ammunition, but *everything* from entering Germany and Austria through any channel, would the grievance against us compare with America's grievance against Germany? And what has the lawyer-President done? Their own *Tribune* speaks of recent months as 'the most disgraceful and shameful in American history'. Over here another aspect of the situation makes its appeal, and we are led to think of Dogberry's orders to the watch :

'This is your charge: you shall comprehend all vagrom men; you are to bid any man stand, in the prince's name.

‘How, if a’ will not stand?’

‘Why, then, take no note of him, but let him go; and presently call the rest of the watch together, and thank God you are rid of a knave.’

Considering the nature of this determined attack on the liberty of the world we had some reason to expect that the style and tone adopted towards us by official America would have been different. Thus McAdoo’s order, put in force in the autumn of 1914, that the clearance papers of outward-bound vessels were to be kept secret until thirty days after departure, seemed a very gratuitous and unnecessary method of inviting international friction. And the President’s last note is characterized by the most wonderful lack of humour. In it the task of championing the integrity of neutral rights is unhesitatingly assumed by the United States. How splendid! At last America will honour her own signature and protest, if nothing else, against the wrongs of Belgium! But, no, what the President appears to have had in mind was the wealth of the Chicago packers!

Representative Mann, the leader of the Opposition in the Lower House in Washington, is quoted as admitting ‘that certainly America was prosperous because of the war, but we would be more prosperous if we were allowed to trade where and with whom we would’. Therefore he foreshadows a political attack on England. Our policy has led not to official friendship or even official tolerance; it has invited the attacks of vampires who would suck the last drop of advantage out of the death-struggle of Europe.

Mr. Dillon is quoted in *The Times* of December 1 as saying in the House of Commons that, if cotton had been made contraband earlier, such action ‘would have embroiled this country with America and the war would

have been hopelessly lost'. The immense majority of Americans would bitterly resent the imputation that their country was more readily stirred to action by a trade interest than by the cold-blooded murder of American women and children. America, as a whole, has high ideals: it is inconceivable that she could sink so low. Americans know, too, that, when they had their 'long row to hoe' in the sixties, Lincoln was not deflected to the smallest degree by our trade interest, and that he confronted a new situation by measures that were new. They know that in a situation more strange and more deadly it is not reasonable to tie us down closely to precedent. That such must be their opinion is indicated in the following extract, which exhibits in a striking manner the situation as it appears to an eminent man of science. It was written June 19, 1915, to a scientific friend, also an American, then resident in England. It is all the more interesting because the situation is regarded so entirely from the outside.

'I was greatly interested in what you said regarding the war. We are all thinking seriously and deeply on the question here. With great reluctance I am forced to the conclusion that Germany is deliberately aiming at world dominion and proposes to use every available means to gain that end. Knowing Germany and Germans as well as I do, I was very doubtful of this at the beginning in spite of what the English said. It becomes every day increasingly clear, however, that Germany of deliberate intent proposes to wage the most effective kind of war that the human mind can conceive of, namely a combination of the highest scientific organization with pure barbarism. I very much doubt whether civilized means of warfare will ever win against this combination if relentlessly pushed to its logical and physical extreme, and so far as I can see Germany has every intention of pushing it just that far. We are unquestionably witnessing the most stupendously interesting step of human

evolution that has occurred since that which differentiated man from the anthropoid—this of course on the assumption that Germany wins, which it seems to me every day more likely that she is going to do. I wish I could think otherwise, but it seems to me that civilized warfare has no chance whatever against uncivilized warfare plus the most superb scientific organization that has ever been put into operation in respect to military affairs.'

Most of us will think that the dangers are here exaggerated, and that, when their help is seriously sought and they are given some initiative and power, British scientific men can do as well or better in the devices of warfare than Germans. The difficulty is to change the attitude of indifference and neglect of which I have been compelled to speak.

The one thing that will benefit America as a whole—I am not speaking of particular industries—is to end the war, and the more completely Germany is isolated the sooner the war will be over. Isolation from the beginning would have ended the war long ago, as I have tried to show in discussing Germany's food-supply. The President's policy all tends to lengthen the war, and I observe that anticipated injurious effects have already received the attention of American financial authorities. Thus, W. S. Kies, vice-president of the National City Bank of New York, was reported on October 27 as having recently spoken of disastrous competition with an impoverished Europe, when 'every man, woman, and child will be compelled to produce. The most rigid economy will prevail, and standards of living will be reduced to a minimum. Not only our foreign markets, but our domestic markets as well, will be in danger.'

A similar but far more serious menace threatens the

neutral countries of Europe. Lord Robert Cecil is reported in *The Times* of December 3 as saying that 'The business of the Foreign Office was to try to make things work smoothly; to secure our rights not only without infringing the rights of neutrals, but also without getting into dangerous and acrimonious disputes'; but these desirable objects can be and have been purchased at too dear a price. Lincoln did not give way in order to make things work smoothly, and the peril of America in the civil war is nothing to the peril of Europe. Surely our position could have been put before neutral nations by a wise and firm diplomacy taking some such line as this: 'The conditions are novel and must be met by greater stringency in order to prevent the war dragging on and bringing financial ruin. To end the war by the means we propose to take will be best for you, best even for Germany. Your trade will be temporarily inconvenienced, but we are prepared to make generous recompense when the war is over or at once in cases of special hardship. England can be trusted to be just.' If only such a firm but friendly policy had been carried out from the very first what misery would have been saved.

I will conclude with a few thoughts on our army's greatest need—a scientific spirit of experiment ever obedient to the call of a swift, alert intelligence. The want has been far more seriously felt in the new conditions of trench warfare than in the comparatively well-known tactics of the first months of the war. It is interesting to reflect that the German army failed completely in the part of the campaign for which it had prepared and towards which it looked with confidence, but that it has been remarkably successful in the unexpected trench warfare. And yet we may be sure

that, if Germany had foreseen a long-drawn struggle, the war would never have begun, and all the misery of the past year and a half would have been spared. Although compelled to fight along lines which her military writers have always condemned, Germany, beaten at the Marne, was ready with a second line of defence at the Aisne. What a contrast between military and psychological intelligence is presented by a nation which has deprived itself of every chance except complete victory ; for it has, of set purpose, so acted in war as to inspire in its foes the iron resolution to conquer or to die.

There is some reason for thinking that the German psychology of war has gone astray because military autocrats have been led to judge of other people by their own. The German subjugation by the State is so excessive that it is but little removed from slavery. Methods of 'frightfulness' are put in force by the slave-driver because he knows by experience that a slave will be crushed into submission by them. The effects that they are likely to produce in a free nation are sufficiently indicated by a letter I have recently received :

' One of my sons sent me a German incendiary bomb which I exhibited here : it was not, however, with the idea of forcing the men to work harder than they were doing, for they were already working as hard as possible, but rather with the idea of bringing the war a little closer home to our men ; for in this little Worcestershire town, than which none is more unmilitary, the war seems a long way off. One of our managers was in London the day after the September Zeppelin raid, and some of the officers took him round to Liverpool Street, and they went through some wrecked buildings which the police had not had time to tidy up. From the sixth-floor front room of this building they picked up handfuls of human remains—flesh, bone, skin, and clothes. He put some of this in a bottle with spirits and brought

it down here and showed it to the men who were working at munitions. This, I believe, did have some effect, or would have had if any stimulus had been needed.'

The German success in trench warfare is entirely due to the use of science. English science, at least equal and probably better, has always been longing to help. The difficulty is to make such help sufficiently available in a country where science has been habitually neglected. We have read again and again that the German flares which guard against night attack are much better than ours. Of course this only means that English chemists have not been asked to discover something better. I will now mention a few other more important matters in which scientific help might with advantage have been appealed to much earlier in the war.

The disaster of Magersfontein immediately raised in my mind the obvious suggestion that the use of smoke as a cover would facilitate approach to an enemy's trench—a suggestion deepened and confirmed by Buller's costly, and for a long time unsuccessful, attempts to relieve Ladysmith. A curtain of smoke rising from a line of smoke-producing shells need not necessarily mean attack on the first, second, or any other particular occasion, but the enemy would be kept in a state of tension and uncertainty favourable to a successful attack when it was finally delivered. Such a method would also be likely to lead to much waste of the enemy's ammunition. We have all read again and again of terribly expensive assaults made on particular positions bristling with machine guns, such as the Hohenzollern Redoubt, and how our men were mown down directly they left their trenches. Not doubting that such attacks could be rendered far less costly, I wrote about a year ago to a friend in the War Office, suggesting

that chemists should be invited to consider the best form of smoke-producing bomb or shell. My friend passed the suggestion on, and it was no doubt carefully pigeon-holed by some military authority. At any rate, there is not the least reason to suppose that it had anything whatever to do with Sir John French's dispatch of October 15 last: 'We attacked the enemy's trenches under cover of a cloud of smoke and gas.' In the same letter it was suggested that the Germans would be likely to use similar methods, and that it was to be anticipated that they would soon pass from smoke as a cover to smoke as an irritant, making it difficult or impossible to breathe in the trenches, and this led to the further suggestion that, although we should never dream of initiating such a thing, we had better experiment so as to be ready if the necessity arose.

Why have not the Germans adopted this obvious device of smoke as a cover? Probably because it would not lead to the kind of fighting in which they excel. My friend Sir Ray Lankester told me the other day of a wounded soldier he had been visiting in a London hospital. The man gave his experience of a German attack: 'Well, sir, they're brave enough, there's no denying it, but their 'eart ain't in it. You see, sir, they ain't a military nation, like us!' Prussian papers please copy!

One sees exactly what the man meant and, in the sense in which he meant it, how true it is.

The appliances that have come in since 1870—smokeless powder, immense precision and range—are on the whole against the peculiar genius of the British soldier. He can learn to use these advantages, indeed to use them splendidly; but they are not natural to him like the weapons of old, when men were directed to reserve:

their fire until they could see the whites of the enemy's eyes, or were even advised, as in Cromwell's day, not to pull the trigger until they could press the pistol against the enemy's body. Directly the range and precision became so great that the soldier needed thought and adaptability, and a keen eye for country, our men were unlikely to excel, except when specially trained from youth. In the Boer War it was well known that if once the British soldier could get into the enemy's trench with his bayonet the position was won. The same thing is true in Flanders to-day, and the cover of smoke is likely to help him to get there.

Other suggestions made at the same time concerned the destruction of barbed wire and the use of armour. My one hope was that scientific men would be invited to experiment. As an indication of what might be attempted, several obvious methods were suggested. I do not mention them, because the obvious in war seems to be so often neglected, and some of them may be still untried by our enemies. But the principal suggestion was that a scientific man should be put in charge of a small range and given every opportunity of experimenting. I was even bold enough to suggest the ideal man for the purpose! His name may still be found in some pigeon-hole at the War Office.

It is necessary to insist that, at the first trial of some new device in the field, the scientific experimenter or his representative should always be present. A new method tried by one who does not believe in it or does not understand it has not the slightest chance of success. At the first trial of the poison gas one of the most distinguished chemists in Germany was in absolute control.

With regard to armour we are given to understand that helmets have now been used for a long time by the

French, while in *The Times* of December 3 Mr. Tennant is reported as saying that 'large quantities have already been sent out and are still being sent out' to our men. The danger of thin armour has often been referred to; but I have never seen the obvious suggestion that for certain purposes heavy armour might be used. I refer to posts of special danger at night, when it is cool and neither quick movement nor heavy loads are necessary: e.g. listening posts, patrolling for enemy snipers, superintending wire, trench work, &c. I am confident that experiments on special armour for men performing such duties as these would have saved many valuable lives.

Many years ago some excitement was aroused by a light bullet-proof shield that, worn by a horse, was tested on a London stage, I think at the Alhambra. The late Rev. F. Jervoise Smith, F.R.S., Millard Lecturer in Engineering at Oxford, was much interested in the exhibit, and made some experiments in his laboratory with encouraging results. I do not mention the principle of his method, which he explained to me, because I believe it to be new, but it is of course at the service of the authorities.

Ever since A. R. Wallace published his *Essays on Natural Selection*, now forty-five years ago, many British naturalists have been keenly interested in the methods by which animals are hidden from their enemies and their prey, and the subject has been more fully studied here than in any other country. We might therefore have expected that when the provision of a concealing uniform was considered the naturalists would have been consulted, or at any rate that known principles would have been studied. So far from this being the case, naturalists saw to their amazement a military cap that

seemed to have been specially designed in order to render the head as conspicuous as possible to the enemy. For naturally this is the effect of the huge flat disk catching the strongest light and further emphasized by sharp contrast with the dark shadow beneath the overhanging brim. I wrote to the War Office on the subject in the autumn of 1914 without producing or expecting to produce any effect. However, about May 12 last I saw in the 'latest news' column of an evening paper that

'Mr. Tennant announced in the House of Commons this afternoon that the flat-topped circular khaki cap had proved too easily visible, and was to be superseded by the softer cap without a wire frame'.

The want of a scientific spirit in the army has been even more conspicuous, and has led to more tragic consequences in the use of men than in the use of material. Professor Spenser Wilkinson, in the *Westminster Gazette* for August 14 last, tells us how he came to the conclusion that the army was not getting the best men from Oxford, and yet that for the war he believed to be coming 'the army would need leaders of the highest stamp, men of the same intelligence as is expected from those who make a mark in the learned professions'. The best soldiers at the War Office agreed with him, and he tried to convert first Lord Haldane and then Mr. Asquith to this view, but neither would do anything.

Then came the national crisis, and instantly, even before it was asked, the flower of our youth, in intellect as in every other quality, was at the disposal of the army. Young Oxford almost in a body began to work for commissions. Some among them, says Professor Wilkinson, were 'men whose ability stamped itself upon

all that they did, men who after eight weeks were writing orders as well as any general in the army'. But after they had held commissions for several months the Professor has been amazed to find that the army is unable to find a special use for the men of special ability. It makes the whole lot into 'second-lieutenants and grades them according to the dates when they joined, so that very often the youngest rank above their elders, and the pupils above their teachers'. And as lieutenants and second-lieutenants they give their lives for England and the world, doing their work splendidly, never complaining, but without any scope for the exercise of the special gifts which distinguish them from the average man.

I have tried in this lecture to show what we have lost by the national neglect of science. There may be some who fear that improvement in this respect would foster the callous materialism and brutality which have been such a shock to the world. But it is not German science which is responsible for the horror, but the German spirit, which has used science, as it has used everything else except a sane psychology, for its own ends. Science, pursued for its own sake because of the enthusiasm, and indeed inspiration, which it calls into being, is in reality one chief bulwark of the modern world against materialism.

I would ask those who have thought that science tends towards a material view of life to read the words written by Charles Darwin to his old teacher and friend, Professor J. S. Henslow, who had maintained that 'however delightful any scientific pursuit may be, yet, if it should be wholly unapplied, it is of no more use than building castles in the air'. Darwin was not satisfied to meet this contention by the reply that the practical use often comes

long after the essential scientific discovery, which, but for the pure love of investigation for its own sake, would never have been made at all. 'For myself', he said, 'I would, however, take higher ground, for I believe there exists, and I feel within me, an instinct for truth, or knowledge or discovery, of something of the same nature as the instinct of virtue, and that our having such an instinct is reason enough for scientific researches without any practical results ever ensuing from them.'¹

Or consider the following conversation. A distinguished American physicist met after many years a friend of his youth who had achieved success in business. He took his friend to the laboratory and showed him an extraordinarily fine grating of ruled lines he had been able to make. The business man listened and looked in silence and then said, 'And what is the use of it?' The physicist replied that by means of this grating the light from distant bodies could be analysed and we could find out, for instance, whether sodium exists in the sun. To this the business man: 'And who in hell cares whether sodium does exist in the sun?' It was a rhetorical question, but an allegory of Sir Michael Foster's supplies the answer. 'It was by curiosity', as I have heard him say, 'that our first parents lost the Garden of Eden; but in transmitting this same curiosity to their descendants they gave us a golden bridge by which we may re-enter Paradise.' And the man who cares whether sodium exists in the sun is to be found there and not in the 'other place.'

The contrast between science itself and its applications has been eloquently put by Huxley in a well-known passage. Speaking of the material advantages he says:

¹ Letter dated Apr. 1, 1848. In *More Letters of Charles Darwin*, i. 61.

'Great is the rejoicing of those who are benefited thereby, and, for the moment, science is the Diana of all the craftsmen. But even while the cries of jubilation resound, and this flotsam and jetsam of the tide of investigation are being turned into the wages of workmen and the wealth of capitalists, the crest of the wave of scientific investigation is far away on its course over the illimitable ocean of the unknown.'

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